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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

EMF3056 – MICROWAVE MEASUREMENT TECHNIQUES (MCE)

30 MAY 2017
9:00 A.M. – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only .
2. Attempt **ALL FOUR** questions .
3. Please print all your answers in the Answer Booklet provided.

Question 1

- a) List FIVE (5) considerations in choosing power measurement equipment. [5 Marks]

- b) The procedures of measuring gain for a power amplifier with pre-amplifier, coaxial attenuators and radio frequency (RF) cables are illustrated below (Figure Q1):

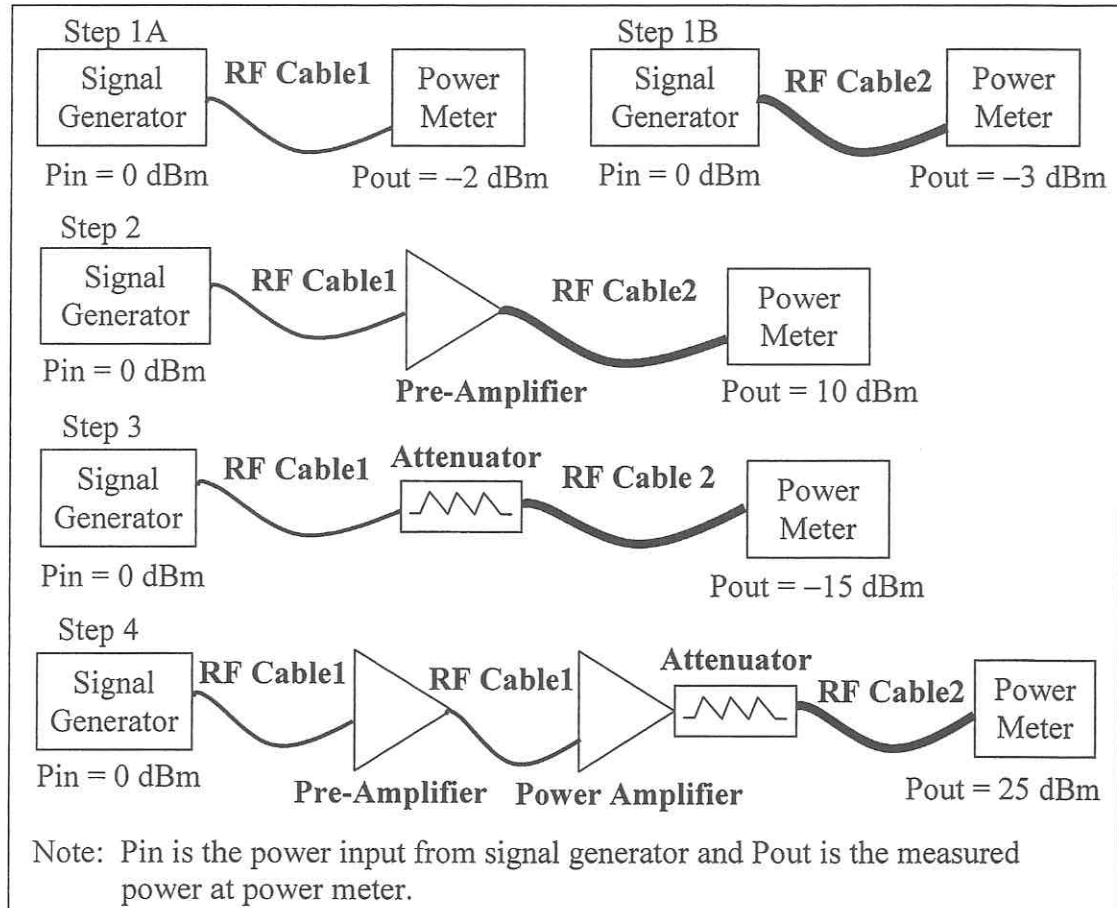


Figure Q1

- (i) State a reason of using a pre-amplifier in the above measurement. [2 Marks]
- (ii) State a reason of using an attenuator in the above measurement. [2 Marks]
- (iii) What are the power losses contributed by the RF cable1 and RF cable2? [2 Marks]
- (iv) Determine the gain of the pre-amplifier. [2 Marks]
- (v) Determine the loss of the attenuator. [2 Marks]
- (vi) Determine the gain of the power amplifier. [4 Marks]

Continued...

- c) The Standing Wave Ratio (SWR) of a RF source under test and the power sensor is 1.67 and 1.22, respectively. Given the calibration factor uncertainty, power reference uncertainty and instrumentation uncertainty is 2%, 1% and 0.5%, respectively, calculate the worst-case uncertainty and root-sum-of-squares uncertainty in dB?

[6 Marks]

Question 2

- a) Explain the principle of operation for a vector network analyzer (VNA) using a block diagram.

[9 Marks]

- b) List FOUR (4) advantages of vector network analyzer (VNA) over scalar network analyzer (SNA).

[4 Marks]

- c) A coaxial filter is connected in between the multi-tone signal generator and spectrum analyzer as shown below in Figure Q2.

(Assume that the connecting cables and connectors have no loss)

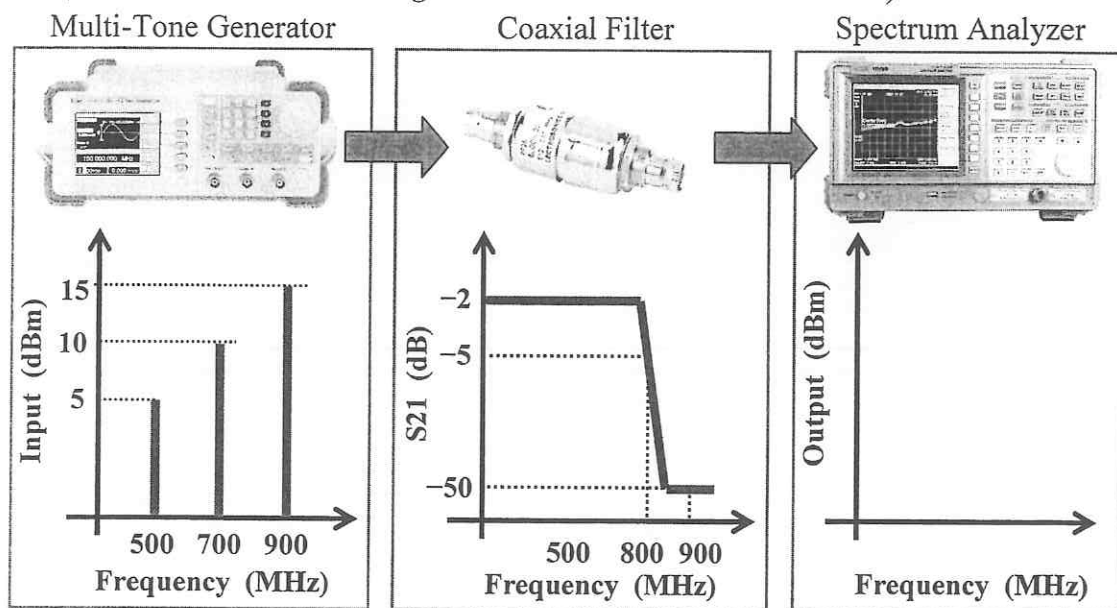


Figure Q2

- (i) Explain briefly THREE (3) functions of filter in a typical microwave communication system.
- (ii) What type of filter is shown in the above measurement?
- (iii) Determine the insertion loss and cut-off frequencies of the filter.

[3 Marks]

[1 Mark]

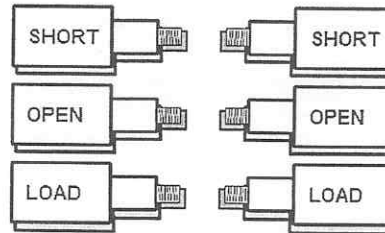
[2 Marks]

Continued...

- (iv) What are the stop-band frequencies and rejections of the filter? [2 Marks]
- (v) Sketch the output of the spectrum analyzer in Figure Q2 above, indicating the frequency points and power level. [4 Marks]

Question 3

A 2-port mechanical calibration standards (as shown in Figure Q3) are used as vector error correction to remove measurement errors.



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Figure Q3

A device under test (DUT) has the following S -parameters at 1 GHz, with a $50\ \Omega$ reference impedance (Z_0) before and after using the above calibration, as shown in Table 1.

Table 1

Before Calibration (Uncorrected)	After Calibration
$S_{11} = 0.5 \angle 10^\circ$ $= 0.492 + j0.087$	$S_{11} = 0.01 \angle 0^\circ$ $= 0.01 + j0$
$S_{21} = 5 \angle 10^\circ$ $= 4.920 + j0.868$	$S_{21} = 10 \angle 20^\circ$ $= 9.397 + j3.420$

- (i) Explain briefly the calibration process used in this measurement. [4 Marks]
- (ii) List FIVE (5) errors removed by the above calibration process. [5 Marks]
- (iii) Explain briefly THREE (3) advantages and THREE (3) disadvantages of the above calibration process. [6 Marks]
- (iv) Determine the input impedance (Z_{in}) of the DUT before and after performing the calibrations. [2 Marks]

Continued...

- (v) Is the input of the DUT matched to $50\ \Omega$ reference impedance, after performing the calibration? Justify your answer. [2 Marks]
- (vi) Determine the input return loss of the DUT before and after performing the calibration. [2 Marks]
- (vii) Is the above DUT has power gain or power loss? Justify your answer. [2 Marks]
- (viii) What is the power gain or power loss of the above DUT in dB before and after performing the calibration? [2 Marks]

Question 4

- a) A super-heterodyne receiver front-end consisting of two amplifiers and a band pass filter are connected together in order to achieve low noise figure configuration (as shown in Figure Q4).

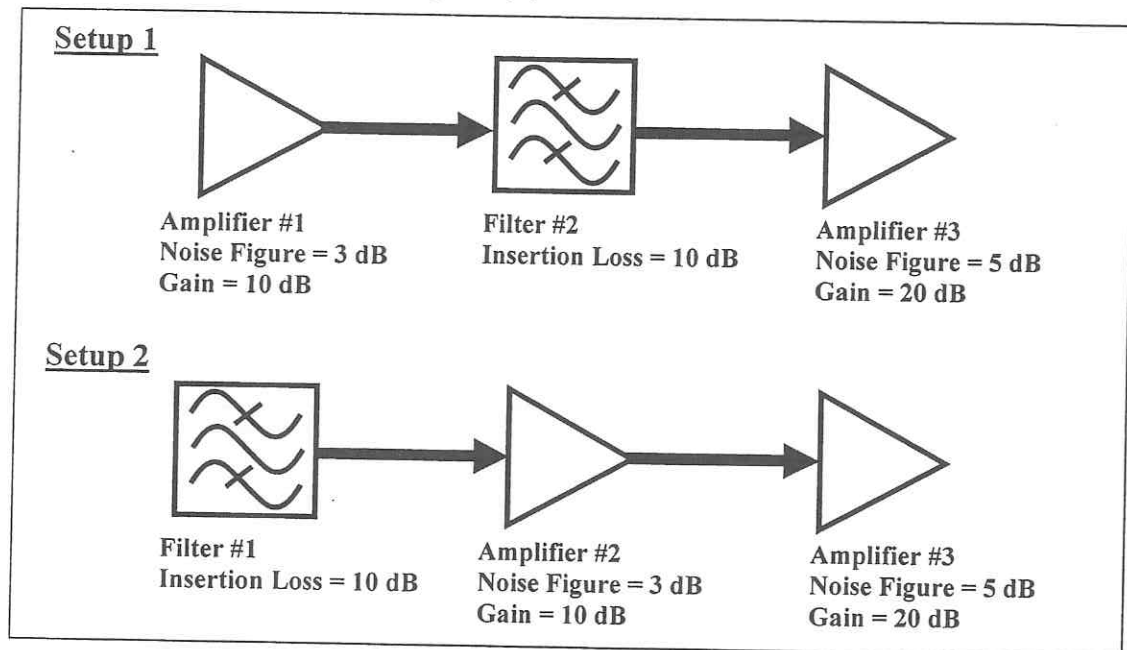


Figure Q4

- (i) Explain briefly the need of band pass filter in a typical super-heterodyne receiver. [2 Marks]
- (ii) Determine the total power gain (in absolute unit and decibel, dB), noise factor and noise figure in Setup 1 and Setup 2. [10 Marks]

Continued...

- (iii) Which setup is recommended for the receiver front end? Justify your answer.
[2 Marks]
- b) Derive the relationship between Noise Figure and Effective Input Noise Temperature of an amplifier.
[4 Marks]
- c) A noise source is connected to a pre-amplifier and the noise power is measured using a spectrum analyzer. The measured hot and cold noise power is -90 dBm and -96 dBm, respectively. Given that the Excess Noise Ratio (ENR) of a noise source is 15 dB. Calculate the noise figure of the system (in dB).
[7 Marks]

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